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M67 HAND GRENADE HEAT TEST

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14. ABSTRACT

The M67 hand grenade is a traditional pull-pin grenade widely used by the U.S. Army and Marine Corps. Pulling the pin in the grenade's fuze (the M213) releases the spoon and the hammer, which hits the primer at the top of the fuze body initiating the firing train. This fuze train is simple and has functioned well and reliably in grenades for decades. Unfortunately, it also has major safety issues. Any unwanted stimulus that causes the primer to function, like fire, initiates the entire fuze train. The large quantities of primary explosive in the detonator can also be detonated by external stimulus with enough energy to function the entire grenade. These problems are exacerbated when many grenades are in the same location, through sympathetic detonation. With the new design of grenade the body, heating tests were conducted on inert wax-filled M67 hand grenades and empty M67 hand grenades to see if grenade halves would separate when heated.

15. SUBJECT TERMS

M67 grenade   M213 fuze   Slow cook-off

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INTRODUCTION

The M67 hand grenade (fig. 1) is a traditional pull-pin grenade, widely used by the U.S. Army and Marine Corps. Pulling the pin in the grenade's fuze (the M213) releases the spoon and the hammer, which hits the primer at the top of the fuze body (fig. 2), initiating the firing train. The delay mix is ignited by the primer and burns several seconds before initiating the attached C70 detonator. This detonator is massive, containing approximately 10 times more lead styphnate, lead azide, and RDX than other detonators such as M55, M61, etc. This size is not simply a case of over engineering; the length is required to properly initiate the grenade's explosive fill for good fragmentation, while its diameter is dictated by the dimensions of the fuze body.

Figure 1
M67 hand grenade

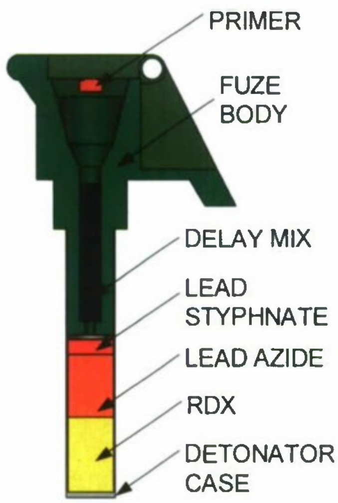

Figure 2
M213 grenade fuze
(spoon and hammer not pictured)

This fuze train is simple and has functioned well and reliably in grenades for decades. Unfortunately, it also has major safety issues. Any unwanted stimulus that causes the primer to function, like fire, initiates the entire fuze train. The large quantities of primary explosive in the detonator can also be detonated by external stimulus with enough energy to function the entire grenade. These problems are exacerbated when many grenades are in the same location, through sympathetic detonation.

This report is a description of heating tests made on inert wax-filled M67 hand grenades and empty M67 hand grenades. The tests were conducted in order to see if grenade halves would separate when heated. Fourteen tests were conducted in all with consistent results.

TEST DESCRIPTION

The M67 hand grenade was modified to meet requirements of the insensitive munitions program. Instead of making the grenade body in one piece it was made in two pieces as shown in figure 3. The modified body was designed to separate when heated, as in a fire, by internal pressures that would rotate the pieces apart. The Detonator and Sensitivity Laboratory Group of Munitions Engineering Technology Center's Explosives Development Branch, U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey was funded to conduct heating tests to see if performance met design goals. Numerous decisions had to be made before the tests could be started. For example: how to heat the item and how fast to heat it, how to collect temperature data, and then how to hold the item while it was being heated. It was decided to collect data using a LabVIEW data acquisition program. The decision was also made to put thermocouples on four spots to get the proper temperature reading of the whole body. Thermocouples were placed on the bottom of the grenade, top of the grenade, middle of the body, and the housing.

Figure 3
Modified M67 grenade w/inert M213 fuze

Several heating methods were considered: propane torch, electric wire, and Sterno® flame. The propane torch method was eliminated because it would require an elaborate test set up and also would be a safety hazard. The flame from a Sterno® can was used initially because it was relatively easy to set up the heating arrangement (fig. 4). Two tests were made with the Sterno® flame. For these tests, thermocouples were placed on the bottom of the grenade (T1), top of the grenade (T2), fuze top (T3), and Sterno® flame (T4).

Figure 4
Sterno® can heater

TEST RESULTS

In the first test, the grenade was suspended over the Sterno® can, which was ignited and the grenade was observed to see if it separated while temperature data was logged into the LabVIEW excel spreadsheet. The grenade temperature reached 300°F with an erratic flame temperature, which was probably caused by flame flicker. The grenade did not separate.

The second test (fig. 5) used a tin can oven to reduce flame flicker. For this test, a tin can was used to hold the grenade to reduce the flame flicker. Thermocouple locations were changed to the middle, top, fuze top, and then on the Sterno® flame. There wasn't much improvement in flame stability with the oven. Data from this test is shown in figures 6 and 7. This method was not chosen as a stable heating method was needed.

Figure 5
Sterno® heater with can oven

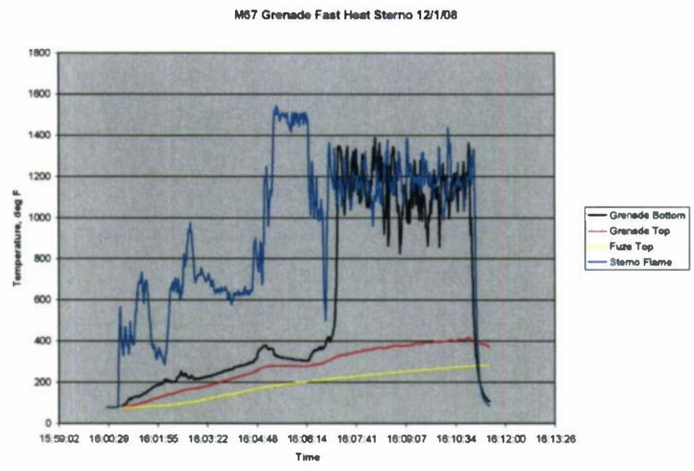

Figure 6
M67 temperature data, Sterno® heater

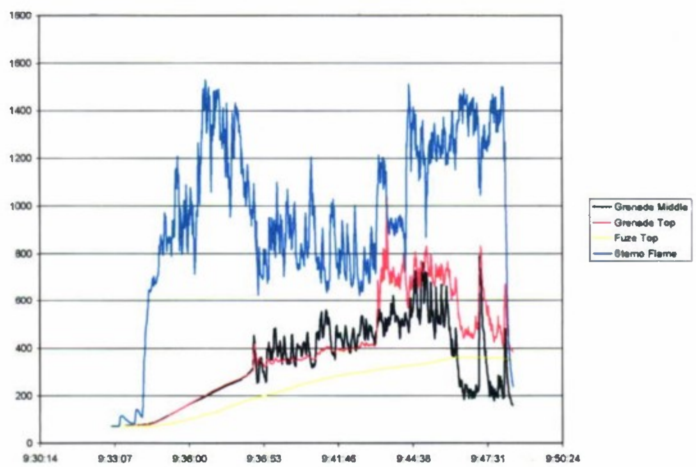

Figure 7
M67 temperature data, Sterno® heater w/can oven

Insulated AWG 20 nichrome heating wire was on hand and it was decided to use the wire to heat the grenade for the remaining tests. It was a challenge to devise a way to heat the grenade with the wire because of the grenade shape. A mesh pad was first woven to hold and heat the bottom of the grenade (fig. 8). Full power at 120 V was applied to the heater wire, which glowed red and then broke when it reached a temperature of 1300°F. Data from this test is shown in figure 9. Four series represents the thermocouple readings at different locations. Series 4 trace was at the bottom of the grenade, series 3 on the fuze housing, series 2 at the middle of the grenade, and series 1 at the top half of the grenade. Later, a better system was devised by placing the heater wire coiled around the top half of the grenade as shown in figure 10. In the first of these tests, 120 V was applied to the heater. Thermocouples were placed at the fuze housing, heater wire, and two locations on the lower grenade body. Shortly after the test was started, the heater wire emitted sparks and then burned out. The voltage was too high for that size heater. The test did not last long enough to acquire sufficient data.

Figure 8
Mesh pad heater

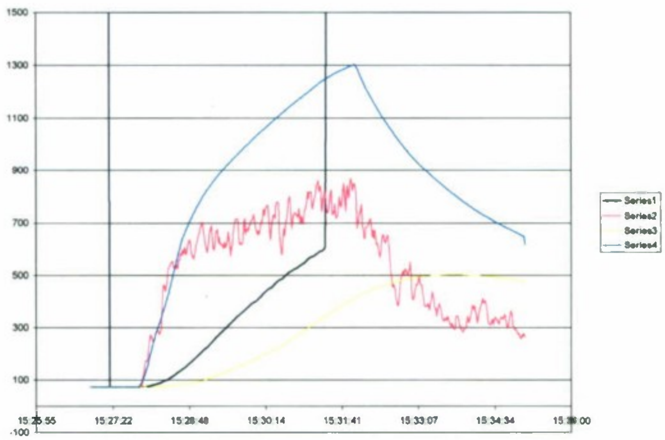

Figure 9
M67 temperature data, mesh pad heater

Figure 10
M67 w/coiled wire heater

For further testing, a resistor was placed in series with the heater wire to reduce power to the wire. Three tests were performed with this method. Temperature data for these tests are shown in figures 11 through 13. Test results were about the same for these tests. The wire insulation first starts to smoke, then the wire glows red and then white, and then starts to burn. Then the wire opens, sometimes accompanied by sparks. The last five tests were controlled with a variable transformer (variac), which gave greater control of the power applied to the heater wire. Figure 14 shows the circuit that was used for these tests. The variac controlled tests lasted longer, but results were similar. The insulation would start to smoke, then the wire would glow red and white, then wax would leak from the grenade seams, and then wax/insulation would burn. Three out of five (first, fourth, and fifth) tests resulted in the fuze threads melting and the grenade separating from the fuze. Temperature data for these tests are shown in figures 15 through 18.

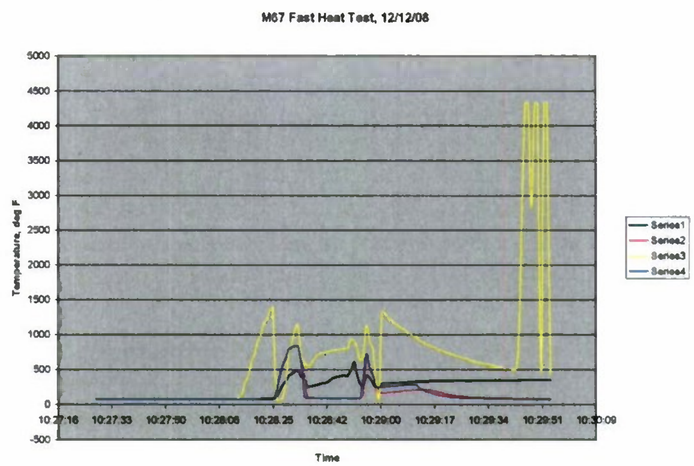

Figure 11
M67 temperature data, 2nd test, coiled wire heater, 120 V w/R

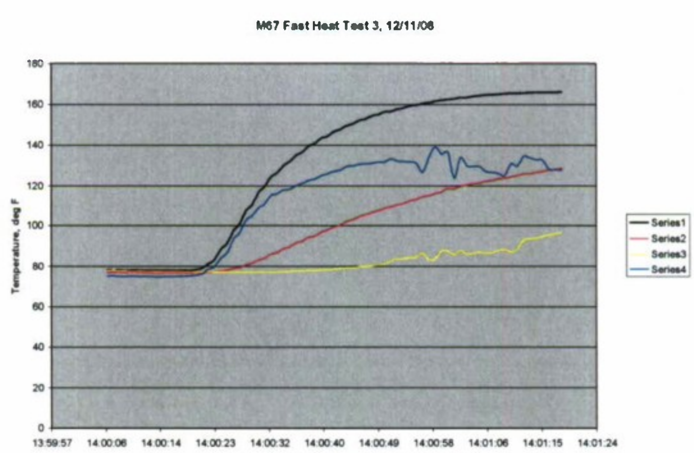

Figure 12
M67 temperature data, 3rd test, coiled wire heater, 120 V w/R

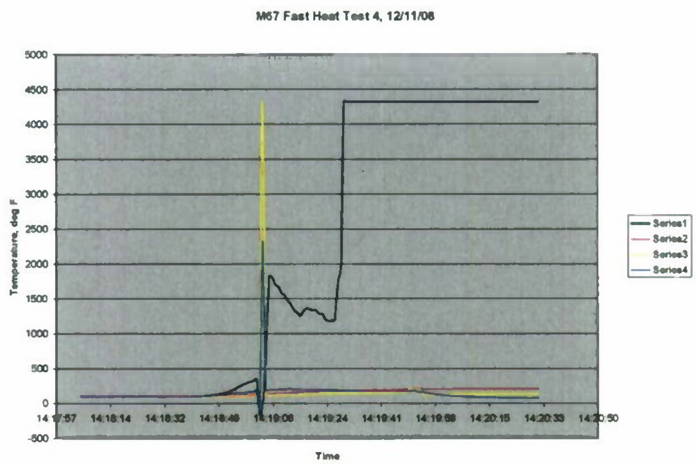

Figure 13
M67 temperature data, 4th test, coiled wire heater, 120 V w/R

Figure 14
Variac heater control circuit

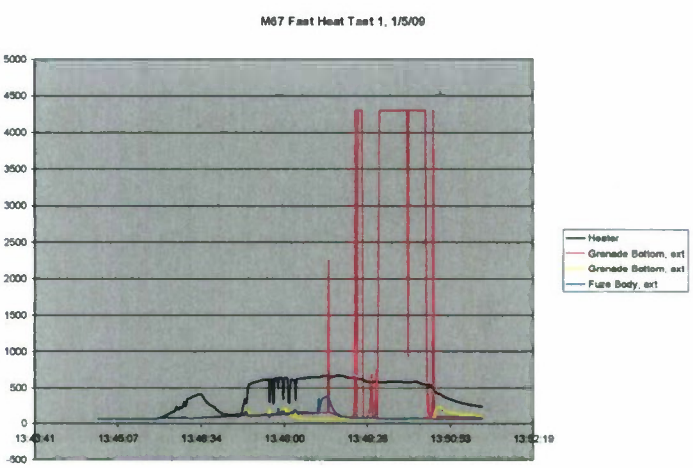

Figure 15
M67 temperature data, 1st test w/coiled heater and Variac control

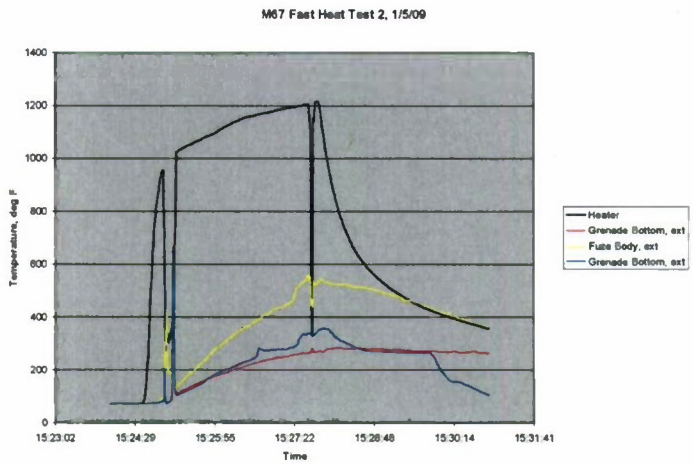

Figure 16
M67 temperature data, 2nd test w/coiled heater & Variac control

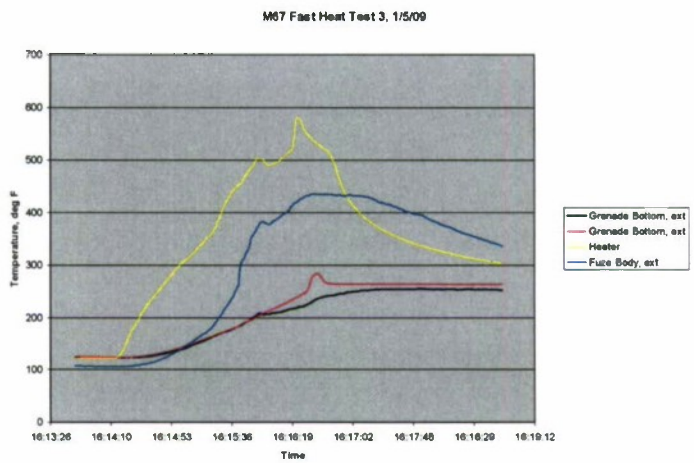

Figure 17
M67 temperature data, 3rd test w/coiled heater & Variac control

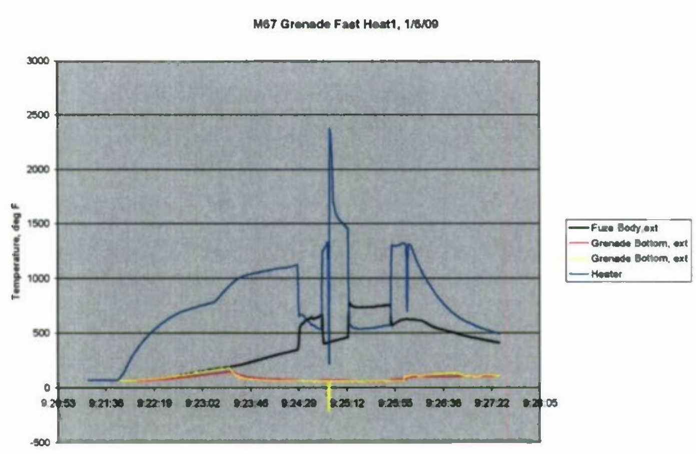

Figure 18
M67 temperature data, 4th test w/coiled heater and Variac control

One test was conducted using an empty grenade body (no wax or any other inert) to see at what temperature the body separates from the fuze. Figure 19 shows data from the last test. The grenade temperature was slowly heated until the grenade body separated from the fuze. The grenade separated around 690°F.

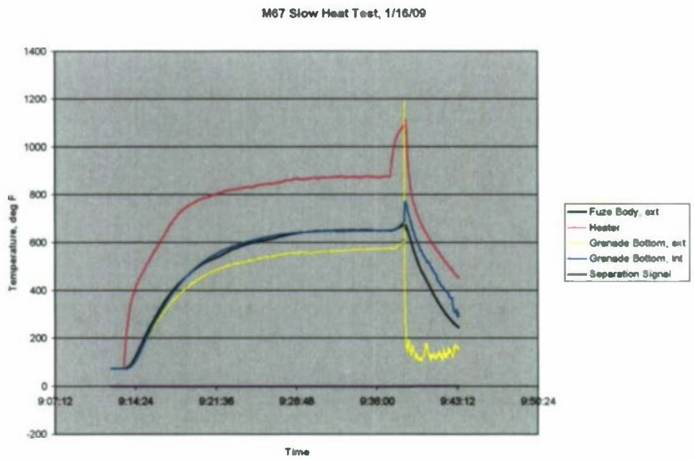

Figure 19
M67 temperature data, 5th test w/coiled heater and Variac control

CONCLUSIONS

None of the tests resulted in the grenade halves rotating and separating from each other although the grenade separates from the fuze in three of the tests. The first thing that happens after applying power is the heater wire insulation starts to smoke, then the insulation glows, first red then white, then at about 180°F the wax filler melts and starts to leak from the seam in the middle of the grenade, then the insulation and wax starts to burn, and if the power is left on long enough the fuze threads melt at about 690°F and the grenade drops away from the fuze. If too much power is applied, the heater wire opens before the grenade separates from the fuze. The grenade separates from the fuze at approximately 690°F.

RECOMMENDATIONS

No recommendations.

DISTRIBUTION LIST

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